Excerpts from "Understanding High Maturity Practices
A Software CMM Tutorial"

Mark C. Paulk

(excerpts presented by Mike Konrad)

**Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890**

This Presentation

The purpose of this presentation is to clarify some of the interpretation issues associated with maturity levels 4 and 5.

Establish a more uniform basis for implementing and appraising high maturity processes, so that organizations:

- **receive more consistent appraisals**
- **realize the intended benefits of higher maturity levels**

Understanding the Principles

There are certain fundamental principles that are crucial to high maturity.

- **approach, deployment, and results are important for "quantitative management"**
  - **without results in terms of improvement trends, is the process truly "mature?"**
- **quantitative process management means**
  - **controlling the (sub)process - not the project**
  - **using data with an understanding of variation**
- **measurable improvement means**
  - **knowing how and when to compare new processes with the baseline - using statistically valid techniques**

Levels 1, 2, and 3

The lower maturity levels build the foundation necessary for “quantitative management”

- **a documented process**
- **acculturation via induction training for new hires, mentoring, etc.**
- **common measures and an organizational measurement database**
- **data for process steps (subprocesses) that has the contextual information necessary for “apples-to-apples” comparison**

What is Level 4 All About? - 1

Quantitative Process Management

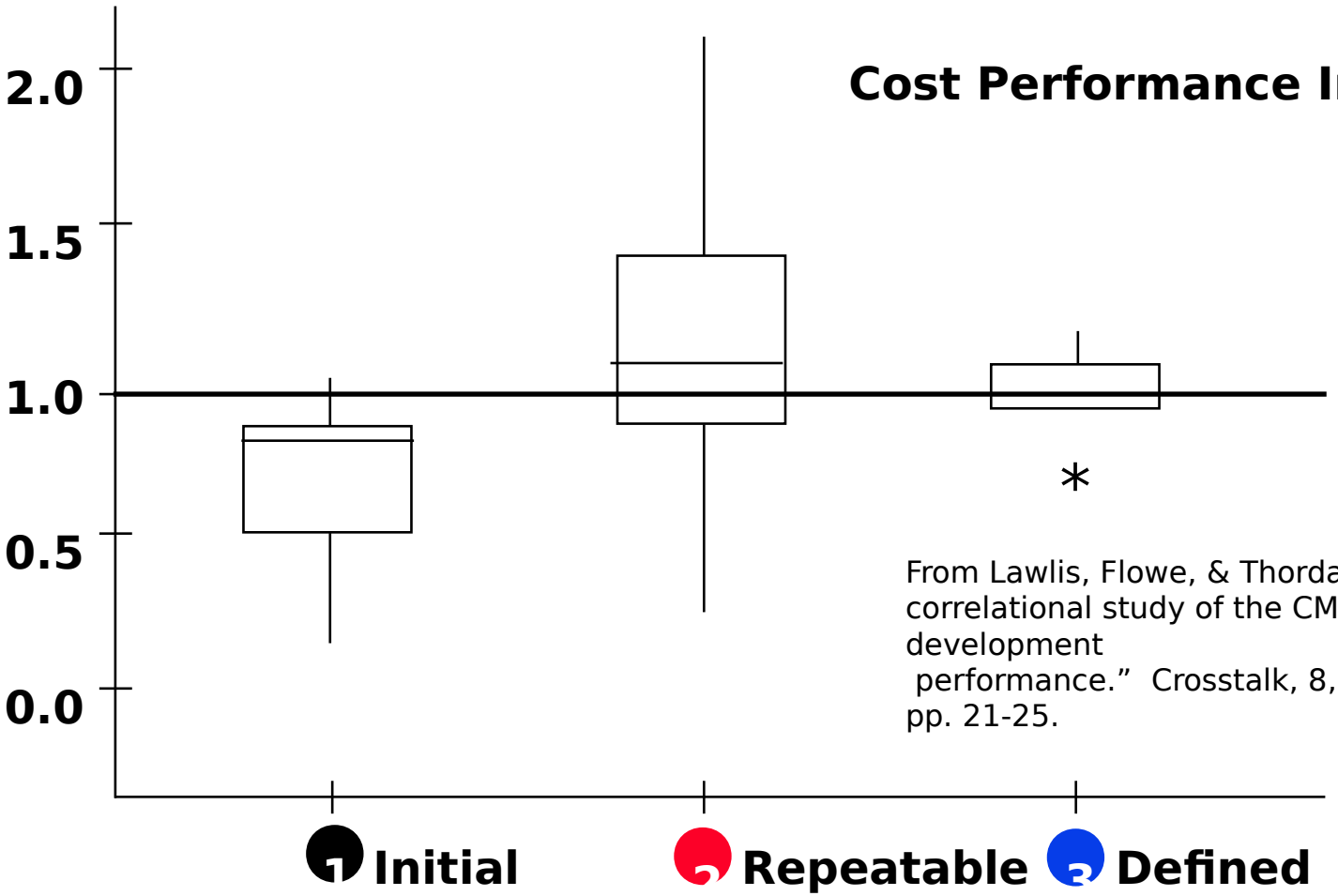
- **determine the most critical subprocesses**
- **identify and measure subprocesses (or process steps) within the development life cycle**
- **understand the natural variation of the critical subprocesses**
- **take action for “assignable causes” to achieve predictable performance results**

What is Level 4 All About? - 2

Software Quality Management

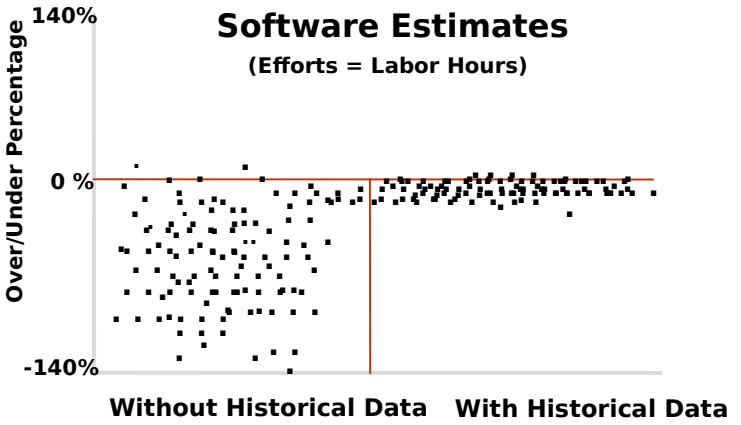
- **establish quality goals**
- **understand the contribution of the critical subprocesses within the life cycle to achieving the goals**
- **incremental improvements can be made from the insight gained into the development life cycle**

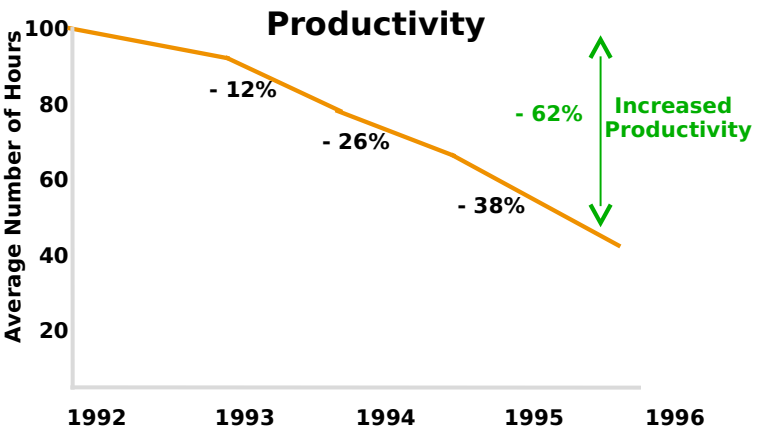
AFIT Study

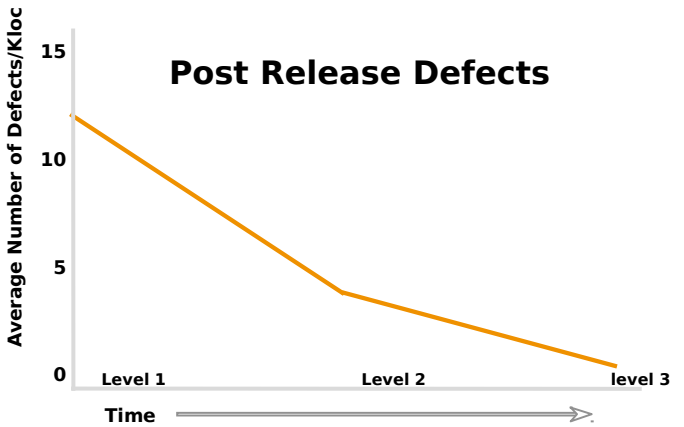


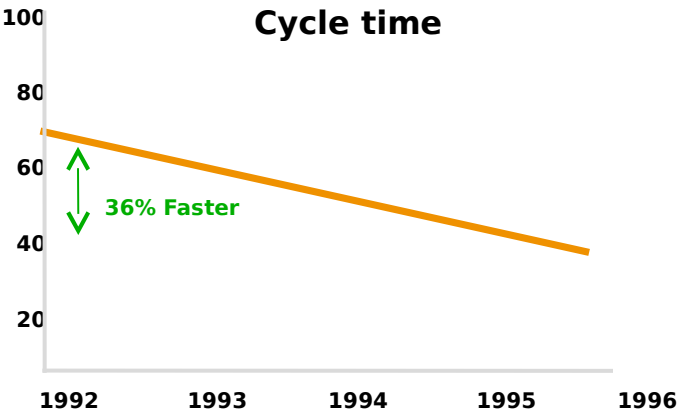
From Lawlis, Flowe, & Thordahl. "A correlational study of the CMM and software development performance." Crosstalk, 8, September 1995, pp. 21-25.

Impact of Software Process Improvement: Boeing Data









John Vu, Boeing, keynote talk at SEPG '97, "Software Process Improvement Journey (From Level 1 to Level 5)"

Project Management

Size estimating was issue in maintenance environment - size may not be critical project planning parameter

- **all 13 survey respondents use lines of code**
- **2 of 13 survey respondents (with 2 piloting) use function points (6 rejected)**
- **8 of 13 survey respondents use cost models**

11 of 13 survey respondents use systematic risk management (and remaining 2 could be characterized as doing so)

Product and Process Assurance

All 13 survey respondents have an independent SQA group and embed the SQA function in the process

11 of 13 survey respondents have independent test groups

- **independent from developers/maintainers**

High Maturity Measurement -1

Dedicated measurement people at project and organization level (may not be full-time)

Goal/Question/Metric flavor

Good operational definitions

Data at process step (subprocess) level

Metric evaluation table: controllable, objective, timely, readily available, etc.

High Maturity Measurement -2

Data collected and used at operational level

Managers and engineers have different data analysis needs

- **engineers use control charts**
- **managers appreciate insights of stable processes**

Sensitive to effect of measurement on behavior

Process Definition and Deployment

Processes owned by practitioners

- **balance between control and empowerment**

Process descriptions provide minimal essential information as organizations move beyond level 3

- **detailed knowledge in training materials, mentors, tools, templates, etc.**

All 13 survey respondents using Internet / intranet/ World Wide Web to deploy process assets

Identify and Measure Subprocesses

Process data is collected at the "process step" level for quantitative process management.

- **engineers use the data to drive technical decision making**
- **examples: design inspections, code inspections, test cases**

Data collected at phase end or on monthly basis is too late for real-time control.

Some exceptions may exist in small projects or maintenance projects.

Monitor Subprocesses

Monitoring subprocesses requires an understanding of variation.

High maturity organizations collect a lot of data (at the subprocess level).

- **to use data for control and comparison, data sources must be categorized - by product family, application domain, etc.**
- **a few important business drivers determine the vital few measures, e.g., cost, schedule, quality**

Measuring Processes

What is the need for measuring processes?

- **to understand the existing performance of the processes**
- **to know the current levels and variabilities of the values that are measured.**

Then, we can proceed to evaluate the information from other perspectives.

To attain control, a process' variability must be stable.

Process Capability

Process capability may be determined for the

- **organization**
- **product line**
- **project**
- **team (Team Software Process℠)**
- **individual (Personal Software Process℠)**

The higher the level of analysis, the greater the variation and the less useful the insight.

Deployment

"All critical" processes should be quantitatively managed.

A reasonable rule-of-thumb for institutionalization is that quantitative management has been in practice for six months.

- **organizations go through an "informally stabilizing the process" phase**

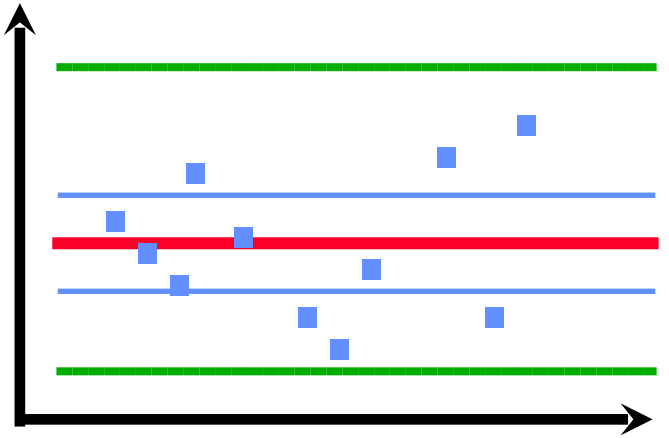
Organizations should demonstrate at least a pilot use of rigorous statistical techniques, such as control charts or prediction intervals.

Statistics Can Lead To Understanding

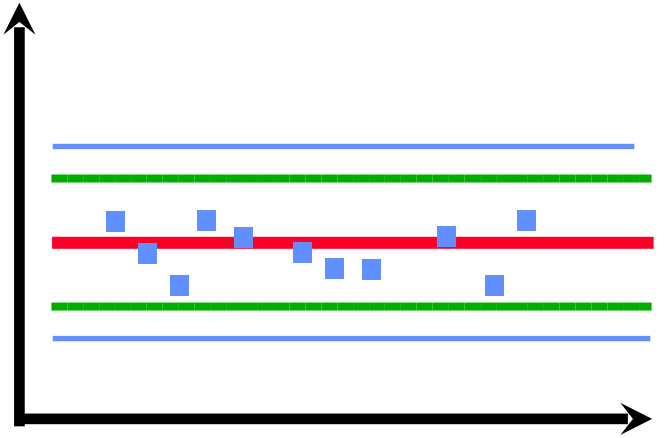
Knowing what is possible with the current process may indicate the kind of management action necessary to achieve those targets!

- **understand variation**
- **changing the system is a management responsibility**

Make realistic commitments



“Voice of the process



Quantitative vs Statistical Thinking

Level 4 of CMM emphasizes "quantitative management" rather than "statistical control"

- **levels 4 and 5 conceptually based on assignable and common causes of variation**
- **most level 4 and 5 organizations appraised using a "relaxed" interpretation of quantitative (statistical) management**

7 of 13 survey respondents (with 4 piloting) using control charts

- **concerns about correct use of control charts**

Listening to Voices

Voice of the process = the natural bounds of process performance

Voice of the customer = the goals established for the product and process performance

Capable process = { stable process + product conformance

Process capability DOES NOT EQUATE TO capable process.

Process capability DOES NOT EQUATE TO capable process.

Addressing the Myths

Myths and misconceptions about SPC for software include

- **Data has to be normally distributed to use control charts.**
- **The software process is too variable for control charts to provide value.**
- **The software process changes too frequently to obtain sufficient valid data for control charts.**

Insufficient Data

The belief that software processes provide insufficient data for statistical analysis seems based on collecting one data point per project.

Control charts should be applied to individual processes, e.g., code inspections.

- **50K SLOC program**
- **100 inspections (data points) at 500 SLOC per inspection**
- **preliminary control limits can be established with 4 or 5 data points**
- **17 data points is usually sufficient for establishing control limits**

Real Challenges to SPC

There are significant challenges to applying SPC to the software process.

- **building good operational definitions**
- **confusing thresholds and control limits**
- **using incorrect statistical techniques**
- **Hawthorne effect - measurement drives behavioral change**
- **causing dysfunctional behavior**

Management Training

Need to train managers on how to use measurement and statistical control

- **effectively to perform their roles**
- **in ways that will not cause dysfunction**

Managers do not "control" the engineering process - engineers do.

- **managers allocate resources, resolve conflicts, and enable engineers to function**
- **managers need to know when to allocate additional resources for addressing an issue**
- **managers need to know performance trends**

Definitions of Quality

Crosby - Quality is conformance to requirements

- **Level 2, *Requirements Management***

Deming - Quality is defined by the customer

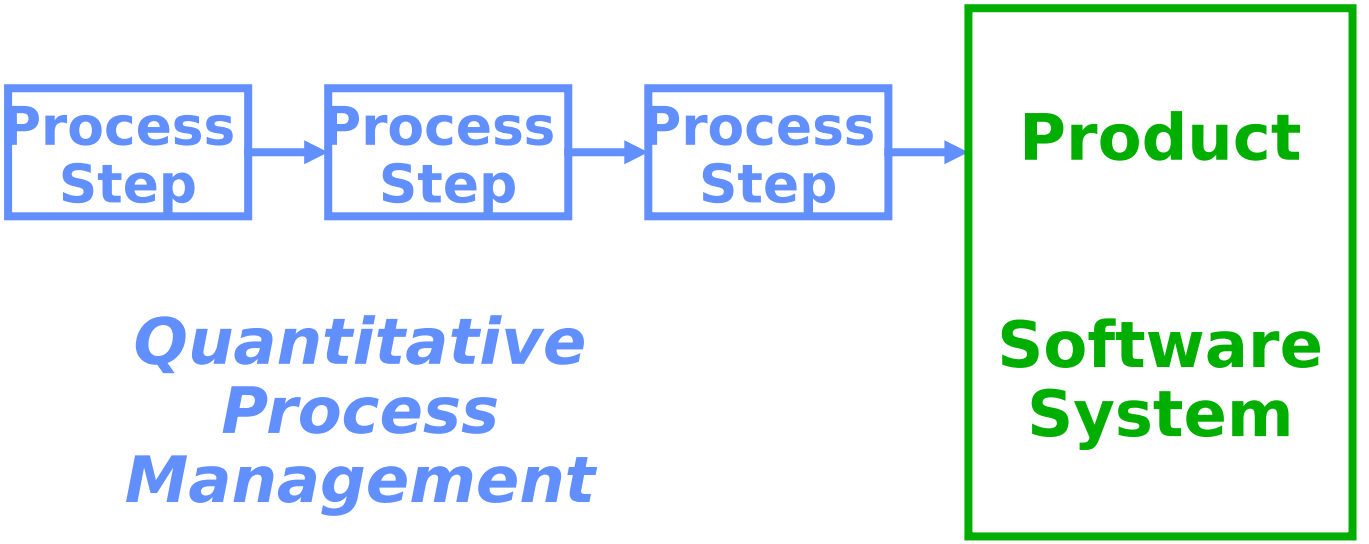
- **Level 3, *Intergroup Coordination***

Juran - Quality is fitness for use

- **Level 4, *Software Quality Management***

The evolution of "quality" is implicit in Software CMM v1.1.

Product vs Process Management



Quality management depends on process management.

Systems Level Perspective

Avoid suboptimization by balancing process management with a systems perspective.

Optimal processes at the (sub)process level will not lead to an optimal solution at the project level!

- **non-intuitive, but well-known, observation from industrial engineering**

Product Knowledge

High maturity organizations systematically attack organizational learning about the application domain and the product.

- **they know what business(es) they are in**

Organizational learning may be captured via

- **systematic reuse with domain engineering**
- **product lines and product families**

High maturity organizations “quantitatively” understand the implications of process change.

Capturing Product and Application Domain Knowledge

7 of 13 survey respondents (with 1 piloting) doing “systematic reuse”

8 of 13 survey respondents (with 2 piloting) have product lines

Every respondent (except one that provided no answer to these two questions) was either piloting or doing systematic reuse / product lines

What is Level 5 All About?

Identify criteria for evaluating new technologies and processes

Use analytical techniques to understand the impact of proposed changes

Provide feedback mechanisms to determine deployment

Self Examination

Think! Reflect! About what you are going to do, about what you have done.

"Kick-off meetings" at the beginning of the project or phase re-synchronize the team.

- **new technologies and processes occur**
- **informed decisions about process deployment need information - from the team**

"Performance analyses" (post-mortems) at the end of the project or phase are learning opportunities.

- **causal analysis of defects prevents defects**

Worker Participation

Continual improvement requires universal participation.

"Empowerment" and "participation" must be balanced against "control."

Should process deployment occur for new projects? The next phase in the life cycle of an on-going project? During execution?

- **"It depends."**
- **What are the interactions? Dependencies?**

Piloting

It may be desirable to pilot significant technology and process changes before deployment.

Choosing not to pilot before deployment can be a “bet-the-business” strategy.

Piloting has other benefits than gathering quantitative performance data.

- **building buy-in for the change**
- **controlling the learning curve**

Pulling Maturity Levels 4 and 5 Together

Maturity Level 4:
Understanding and managing the variation in the process to achieve the quality goals.

Maturity Level 5:
Use the knowledge available from quantitative management to select and deploy incremental improvements as well as innovative technological improvements.

Subtle But Fundamental -1

Level 4 organizations:

- **collect data and control the process at the subprocess level**
- **incorporate an understanding of variation into process control**
- **balance project and process perspectives at the “systems” level**

Subtle But Fundamental -2

Level 5 organizations:

- **think about the process - before and after**
- **encourage universal participation**
- **identify the criteria for evaluating change up front**
- **use sophisticated statistical techniques where appropriate**

General SEI Information

SEI Customer Relations +1 (412) 268-5800

SEI FAX number +1 (412) 268-5758

Internet Address
customer-relations@sei.cmu.edu

Mailing Address
Customer Relations
Software Engineering Institute
Carnegie Mellon University
4500 Fifth Avenue
Pittsburgh, PA 15213-3890

Internet Access to SEI

SEI Web pages

- ***www.sei.cmu.edu***
- ***www.sei.cmu.edu/cmm/***
- ***www.sei.cmu.edu/cmm/cmm.articles.html***